

Investigation of the treatment efficiency with mandibular advancement appliance therapy on snoring and mild obstructive sleep apnea

Treatment efficiency of MAD therapy on snoring and mild OSA

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Abstract

Aim: The correct repositioning of the mandible and the design feature of the appliance have a key role in the success of mandibular advancement device (MAD) therapy in obstructive sleep apnea (OSA) treatment. There is still a dilemma on the most effective mandibular advancement and vertical opening amount, titratability, material and piece number of the MAD appliances. This study was performed to identify the treatment efficiency of a modified monobloc style, untitrable MAD constructed from silicone material, which has 75% of the maximum protrusion mandibular advancement amount and a 6 mm vertical opening.

Material and Methods: 15 snoring and mild OSA patients were included in this study. Polysomnography tests and cephalometric analysis were done during pretreatment and after 8 weeks of ordinary MAD use, with MAD in mouth. Linear and area measurements were done on the lateral cephalometric films. The results were analyzed with a paired comparison t-test.

Results: Significant reductions occurred in Total Apnea Hypopnea Index, Total Hypopnea Index, Arousal+Awakening Number ($p < 0.05$) and Awakening Number ($p < 0.01$). Significant increases were found in Oropharyngeal and Hypopharyngeal Airway Dimensions ($p < 0.05$), the narrowest sagittal dimension of the pharyngeal airway ($p < 0.01$), Tongue Area, Oral Area, Oropharyngeal Area and Nasooropharyngeal Area ($p < 0.01$).

Discussion: Modified monobloc style, unadjustable MAD, constructed from dental silicone material, with 6 mm vertical opening and 75% of the maximum protrusion mandibular advancement amount was found to be an effective treatment alternative for snoring and mild obstructive sleep apnea.

Keywords

Obstructive Sleep Apnea, Snoring, Mandibular Advancement Appliance Therapy

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Introduction

Obstructive sleep apnea (OSA) is a sleep-related breathing disorder which is characterized by recurrent episodes of partial or complete upper airway obstructions, blood oxygen desaturation, sleep arousal and/or awakening during sleep. It leads to severe long-term health problems as a result of the decrease in blood pressure during apnea and hypopnea episodes. Apnea is the cessation of breathing for 10 seconds or more. Hypopnea is a decrease of 30-90% of normal airflow in breathing, for at least 10 seconds. Increased risk of high blood pressure, heart diseases, heart attacks, heart failure, pulmonary hypertension and stroke can be seen in OSA patients. People from all ages, even pediatric and adolescent ages can be affected, but middle ages have the highest prevalence. OSA prevalence is estimated at 3-7% in men and 2-5% in women. Snoring, excessive daytime sleepiness, morning headache, mood changes like nervousness or depression and difficulty concentrating are the symptoms of OSA. Snoring is the most evident symptom of OSA. Every OSA patient snores, but every snoring person is not an OSA patient. The etiology of OSA is multifaceted involving genetic, craniofacial, anatomical, neuromuscular and inflammatory factors whose contributions differ from patient to patient [1, 2, 3].

OSA treatment is performed by a multidisciplinary team consisting of medical doctors and dentists. Treatment approach should be chosen according to the severity of the disorder. OSA is classified as mild, moderate or severe depending on the Apnea-Hypopnea Index (AHI). AHI<5 is considered normal. AHI between 5-20 represents mild, AHI between 21-40 represents moderate and AHI >40 represents severe OSA [4].

The American Sleep Disorders Association reported that oral appliance therapy is the primary treatment option for snoring and mild OSA patients. There are three kinds of oral appliances for snoring and OSA treatment. They are Mandibular Advancement Devices, Tongue Retaining Devices and Palate Lifting Devices. Mandibular Advancement Devices (MAD) are the most popular and the most effective type of oral appliance. MADs, reposition the mandible to a more forwarded position. This advancement stretch and stabilize the attached soft tissues and tongue, which increases the tension of the genioglossus, supra and infrahyoid muscles. In doing so, it enlarges the airway in the oropharyngeal and hypopharyngeal regions. However, the design feature and the correct repositioning amount of the mandible have a key role in the success of MAD therapy. Inadequate positioned mandible and incorrectly designed MAD decrease treatment efficiency and patient cooperation. The literature does not provide consensus on the most effective mandibular advancement and vertical opening amount, piece number, titrable or non-titrable choice and construction material of MAD appliances [4, 5, 6].

The aim of this study is to identify an effective mandibular protrusion amount, vertical opening amount and design feature for MAD therapy in mild OSA treatment.

Material and Methods

This study includes 15 patients, aged 31 to 69 years, (mean age 49.07, SD 9.88; 8 females and 7 males) who were diagnosed with mild OSA at Gazi University Faculty of Medicine, Sleep

Disorders Center. They were referred to the Gazi University Faculty of Dentistry, Department of Orthodontics for oral appliance therapy.

The inclusion criteria were: (1) Snoring and Mild OSA patients with AHI= 5-15; (2) Subjects with good oral hygiene and periodontal health; (3) Subjects who have at least 8 teeth at one jaw. The exclusion criteria were: (1) Moderate to severe OSA patients, with AHI > 20; (2) Patients with severe health problems; (3) Subjects with TMJ disorders.

The sample comprised lateral cephalometric films and polysomnography reports obtained pretreatment and after 8 weeks of ordinary use of appliance with MAD in mouth. Linear and area measurements were done on the lateral cephalometric films.

Oral Appliance

A modified monobloc type, teeth and tissue supported, one pieced, soft silicone material, unadjustable MAD appliance was applied to the subjects included in this study. The mandibular advancement amount was 75% of the maximum protraction and the vertical opening amount was 6 mm. Silasto 70 (Dr. Hinz Dental, 97-406) dental silicone material was used to construct the appliance (Figure 1).

When MADs were applied to the patients they were informed how to use the appliance and instructed to use the MAD every night. Control appointments were given to the patients after 1 and 2 weeks of use of MAD. At control appointments, the patients were investigated for tissue irritations, TMJ pain, tooth hypersensitivity and compliance.

The 8 weeks of ordinary use of MAD, after patient compliance observation, were regarded as the outcome measuring time for this current study.

Cephalometric Investigation

All films were obtained in natural head position, by the same radiology technician, with the same Orthopantomograph Instrumentarium device. Pretreatment cephalograms were taken in centric occlusion. Posttreatment cephalograms were taken with MAD in mouth. Linear and area measurements were done on each radiograph for investigation of the changes in airway dimensions and airway areas. Figure 2 shows the linear measurements and Figure 3 shows the area measurements. Both linear and area measurements were performed by the same orthodontist. The area measurements were done with Placom KP-90N digital planimeter.

Polysomnographic Investigation

The patients undergone polysomnographic analysis at Gazi University Faculty of Medicine, Sleep Disorders Center. The tests were performed with Somnostar computer aided PSG device with Alpha programme by the same sleep technician. 9 polysomnographic parameters were taken into consideration in this study. Total sleep time, Sleep efficiency, Arousal Number, Awakening Number, Arousal+Awakening Number, Total Apnea Index, Total Hypopnea Index, Total Apnea+Hypopnea Index and Minimum oxygen saturation were evaluated in PSG tests. Total Sleep Time is the total amount of sleep time scored during the total PSG recording time. Sleep Efficiency is the ratio of total sleep time to time in bed. Arousal Number is the number of shifting from deep sleep (REM sleep) to light sleep (non-REM sleep) during the total PSG recording time. Awakening Number

is the number of shifting from sleep to awakening during the PSG total recording time. Arousal+Awakening Number is the sum of arousal and awakening numbers during the total PSG recording time. Total Apnea Index is the index obtained by dividing the apnea index to sleeping hour. Total Hypopnea Index is the index obtained by dividing the hypopnea index to sleeping hour. Total Apnea+ Hypopnea Index is the index obtained by dividing the sum of apnea and hypopnea numbers to sleeping hour. Minimum Oxygen Saturation is the minimum oxygen level detected during the total PSG recording time.

Statistical Analysis:

The statistical analysis performed on the parameters obtained from cephalometric films and polysomnography reports. The statistical analysis performed with SPSS 15.0 programme. Paired samples t-test was used to analyze the differences in cephalometric and polysomnographic parameters, before MAD therapy and with MAD. The inter-examiner reproducibility on cephalometric investigation for airway area and airway dimension measurements were done too. Repeating cephalometric analysis were done on random selected 10 patients, by the same orthodontist, one week apart from the first measurement. Random selected 3 linear and 3 area measurements inter-class confidence coefficients were calculated. Inter-class confidence coefficients were calculated between 0.95-0.99.

Ethical Approval

This study was approved by the Academical Board of Gazi University, Dentistry Faculty, Department of Orthodontics (Date: 2004-07-23, No: 21.33.1335).

Results

Linear Measurement Results

Linear cephalometric investigations showed that the horizontal and superoinferior position of the hyoid bone changed significantly ($p < 0.05$), the vertical position of the hyoid bone changed significantly ($p < 0.01$) with MAD in mouth. The vertical position of vallecula did not change significantly, but the horizontal position change was statistically significant ($p < 0.05$) with MAD. Significant increases were found in airway dimensions with MAD in mouth. Oropharyngeal Airway Dimension ($p < 0.05$), Hypopharyngeal Airway Dimension ($p < 0.05$) and the narrowest sagittal dimension of the pharyngeal airway ($p < 0.01$) increased significantly (Figure 2) (Table 1).

The definitions of the linear measurement parameters and cephalometric reference planes are written below.

- 1) 1-NA 2) 1-NB 3) Overjet 4) Overbite 5) Tongue Length (VT): The linear distance between V point and tip of the tongue.6) Tongue Height: A line drawn perpendicular from the most superior point of tongue dorsum to the VT line. 7) PM'-U: Soft palate length 8) SPT: The maximum thickness of the soft palate 9) PM'-UPW: Nasopharyngeal airway dimension 10) U-MPW:Oropharyngeal airway dimension 11) V-LPW: Hypopharyngeal airway dimension. 12) PASmin: The narrowest sagittal dimension of the pharyngeal airway 13) V-FH: The vertical position of the Vallecula 14) V-CV: The horizontal position of the Valleculta 15) H-FH: The vertical position of hyoid bone according to FH plane, 16) H-CV: The horizontal position of the hyoid bone 17) H-MP: The vertical position



Figure 1. Oral appliance

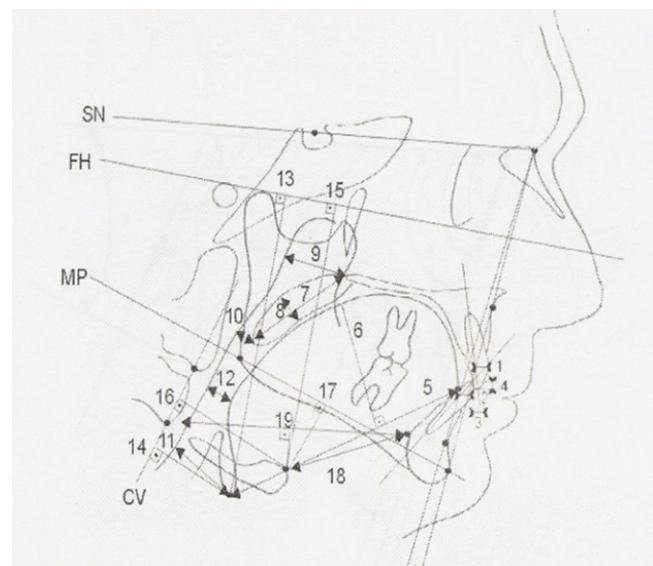


Figure 2. Linear measurement parameters and cephalometric reference planes

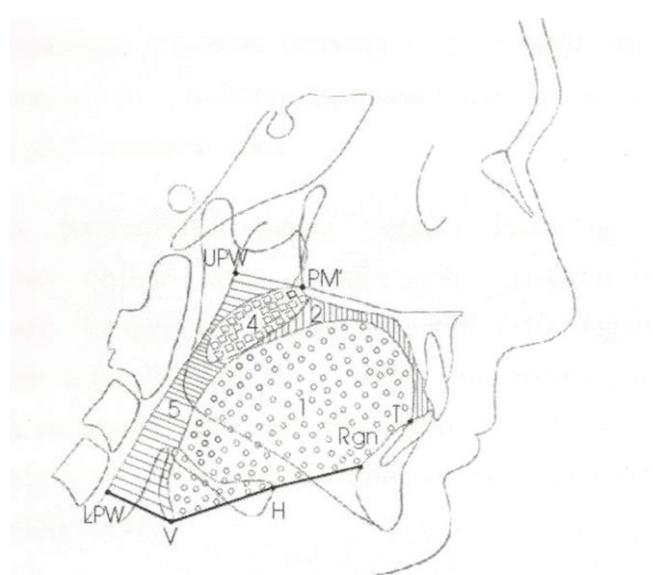


Figure 3. Area measurements

of hyoid bone according to mandibular plane 18) Rgn-H: The horizontal position of the hyoid bone according to mandibula 19) H \perp C3Rgn: The superoinferior position of hyoid bone, Reference Planes: SN Plane: The line between S and N points. FH Plane: The line between Po and Or points. CV Plane : The line between the most anteroinferior points of the second and the third cervical vertebrae. MP : The line between Go and Gn points.

Area Measurement Results

The area measurements performed on lateral cephalometric

films showed that significant changes occurred in airway areas with MAD type oral appliance therapy. Tongue Area ($p < 0.01$), Oral Area ($p < 0.01$), Oropharyngeal Area ($p < 0.01$), and Nasooropharyngeal Area (Total Airway Area) ($p < 0.01$) demonstrated a significant increase (Figure 3) (Table 2). The definitions of the area measurements are written below

1. Tongue Area (TA): The cross-sectional area outlined by the dorsum of the tongue surface and the lines that connect T, Rgn, H and V points. 2. Residual Oral Area (ROA): The cross-sectional area outlined by the superior contour of the tongue and the

Table 1. Linear Measurement Results

Measurements	Preappliance		With Appliance		Difference		
	X	Sd	X	Sd	X	Sd	p
Overjet	3,56	2,03	0,13	1,26	-3,43	1,51	p< 0.01
Overbite	4	2,19	-8,06	1,97	-12,06	2,8	p< 0.01
VT	84	7,3	83,37	6,36	-0,7	7,27	NS
Tongue Height	37,53	6,74	41,83	7,47	4,3	4,47	p< 0.05
PM'-U	42,53	4,49	43	4,4	0,46	2,19	NS
SPT	11,66	1,87	11,66	1,87	-	-	-
PM'-UPW	28,63	2,21	29,16	2,51	0,53	0,93	NS
U-MPW	8	2,86	8,93	3,24	0,93	2,15	p< 0.05
V-LPW	17,57	9,96	18,83	9,87	1,26	1,95	p< 0.05
PASmin	7,3	3,6	8,73	3,97	1,43	1,2	p< 0.01
V \perp FH	91,73	15	91,2	14,93	-0,53	4,32	NS
V- CV	23,03	10,42	22,2	10,66	-2,83	3,23	p< 0.05
H \perp FH	98,93	9,35	98,6	8,67	-0,33	5,33	NS
H \perp MP	20,1	6,73	16,6	5,58	-6,06	6,86	p< 0.01
Rgn-H	39,63	6,44	37,17	6,5	-3,46	4,7	p< 0.05
H \perp C3Rgn	12,93	5,91	9	4,98	-3,93	5,75	p< 0.05
H- CV	39,97	7,95	41,03	7,32	3,06	3,58	p< 0.05

Table 2. Area Measurement Results

Measurements	Preappliance		With Appliance		Difference		
	X	Sd	X	Sd	X	Sd	p
Tongue Area (TA)	33,32	4,59	35,70	3,89	2,38	1,57	p< 0.01
Residual Oral Area (ROA)	3,99	1,06	4,10	0,80	0,11	0,93	NS
Oral Area (OA)	37,31	4,44	39,81	3,98	2,49	1,61	p< 0.01
Soft Palate Area (SPA)	3,93	0,67	3,93	0,67	-	-	-
Oropharyngeal Area (OPAA)	7,50	2,98	8,78	3,79	1,28	1,17	p< 0.01
Nasooropharyngeal Area (NOPA)	48,75	7,21	52,55	7,13	3,80	1,54	p< 0.01

Table 3. Polysomnographic measurement results

PARAMETER	Preappliance		With Appliance		Difference		
	X	Sd	X	Sd	X	Sd	p
Total Sleep Time	313,60	53,10	326,10	74,70	12,50	74,68	NS
Sleep Efficiency	77,79	10,44	77,16	15,14	2,37	11,40	NS
Arousal Number	69,80	42,30	53,37	34,34	-16,39	41,13	NS
Awakening Number	31,73	13,45	17,33	13,64	-14,40	17,38	p< 0.01
Arousal+Awakening Number	105,40	40,20	72,60	44,80	-32,80	55,70	p< 0.05
Total Apnea Index	3,16	2,55	2,90	4,42	-0,26	2,33	NS
Total Hypopnea Index	10,6	11,29	3,46	3,18	-6,6	10,8	p< 0.05
Total Apnea Hypopnea Index	9,78	3,47	5,47	4,83	-4,31	6,32	p< 0.05
Minimum Oxygen Saturation	92,33	1,49	92,73	0,47	0,40	1,95	NS

external contours of hard and soft palate. 3. Oral Area (OA): The sum of tongue area and residual oral area. 4. Soft Palate Area (SPA): The cross-sectional area outlined by the anterior and posterior contours of the soft palate. 5. Oropharyngeal Area (OA): The cross-sectional area outlined by the PNS, UPW, LPW and V points. 6. Nasooropharyngeal Area (NOPA): The sum of the tongue area, residual oral area, soft palate area and oropharyngeal area.

Polysomnographic Analysis Results

Respiratory evaluations showed that significant reductions were found in Total Apnea Hypopnea Index, Total Hypopnea Index, Arousal+Awakening Number ($p < 0.05$) and Awakening Number ($p < 0.01$) (Table 3).

Discussion

MADs were regarded as the most effective therapy for snoring and mild OSA, but the design feature of the appliance changed the success rate and patient compliance. The success rate of the MAD is affected by the material, piece number, titratability and horizontal-vertical mandibular replacement amounts of the appliance.

Tissue and tooth supported oral appliances are more stable in mouth due to occupying greater oral areas and spreading the oral forces homogeneously. MAD appliances constructed from soft dental materials have better patient compliance because they occur less destructive oral forces, tooth hypersensitivity and tissue irritations. [5, 6, 7, 8]

One-pieced or two-pieced appliance design does not affect the treatment success significantly. Many studies have shown that if the oral appliance has good stability, the piece number of the appliance does not affect the treatment result [5, 6, 7, 8, 9, 10]. The titratability of the appliance was found insignificant too in the treatment success of the oral appliance therapy. The literature review has shown that when the oral appliance prevents the airway obstruction and enlarges the airway properly it shows treatment efficiency regardless of titrability option [5, 6, 7, 8, 9, 10, 11].

The mandibular replacement amount is the most important criteria on MAD treatment efficiency. Especially the mandibular protrusion amount is very important in treatment success. However, there is no consensus on both the maximum protrusion and the vertical opening amount.

The literature has shown that the ideal mandibular advancement amount should be between 50% and 75% of the maximum protrusion amount of the mandible [5, 6, 7, 8, 9, 10, 12, 13, 14]. The researches prefer different vertical opening amounts, varying from 1 mm to 14 mm. The literature review has shown that if the vertical opening amount of the mandible is greater than the protrusion amount, there will be inefficient hypopharyngeal airway enlargement. Because increased vertical dimension causes posterior mandibular rotation which reduces the pharyngeal airway area [14, 15, 16, 17]. Mayoral et al. [17] reported that every 1 mm of vertical increase, up to 8 mm of interincisal distance, leads 0.3 mm reduction in mandibular advancement amount. In this current study 6 mm mean vertical opening amount was selected in order to obtain an effective vertical opening, without any reduction in mandibular protrusion.

Modified monobloc style, one-pieced, tooth and tissue supported, unadjustable, MAD appliance with 6 mm vertical opening and sagittal advancement amount of %75 maximum protrusion, constructed from dental silicone material was used in this current study in order to use all recommended MAD design features in literature.

Our results demonstrated that both airway dimensions and airway areas increased significantly with MAD in mouth. Statistically significant changes was found in the horizontal, vertical and superoinferior position of the hyoid bone. This changes can be explained by the forward and downward position of the mandible with MAD. The vertical position of vallecula did not change significantly but the horizontal position change was found to be significant. ($p < 0.05$) The insignificant vertical position change and significant horizontal position change of vallecula is due to our MAD appliance design. The MAD appliance used in this current study aimed for more effective mandibular protrusion than vertical opening of the mandible. Significant increases occurred in the Oropharyngeal Airway Dimension ($p < 0.05$), Hypopharyngeal Airway Dimension ($p < 0.05$) and the narrowest sagittal dimension of pharyngeal airway ($p < 0.01$) with MAD appliance. Our results showed similarity with other studies [18, 19, 20, 21, 22, 23, 24, 25]. These findings are also important to identify the enlargement levels of the pharyngeal dimensions. The MAD appliance with 6 mm vertical opening and 75% maximum protrusion amount used in this current study enlarged the pharynx at retropalatal and retroglossal levels.

In the present study, significant changes occurred in airway areas with MAD in mouth. Tongue Area ($p < 0.01$), Oral Area ($p < 0.01$), Oropharyngeal Area ($p < 0.01$), and Nasooropharyngeal Area (Total Airway Area) ($p < 0.01$) demonstrated a significant increase. The changes in tongue area vary in literature. Statistically significant increase, unsignificant increase or statistically significant decrease can occur in tongue area. The statistically significant increase in tongue area in this current study can be explained by the forward movement of V,H and Rgn points with mandibular protrusion occurring with MAD in mouth. The statistically significant increases occurred in Oral Area ($p < 0.01$), Oropharyngeal Area ($p < 0.01$), and Nasooropharyngeal Area (Total Airway Area) ($p < 0.01$) shows similarity with the literature [18, 19, 20, 21, 22, 23, 24, 25]. These increases in airway areas are due to mandibular protrusion. The mandibular protrusion increases the distance between the soft palate and the posterior pharyngeal wall and enlarges the space between the tongue root and the posterior region of the oropharynx. Also, the vertical opening amount of 6 mm was chosen in order to prevent excessive posterior rotation of mandible and reduction in mandibular protrusion amount.

Beneficial changes occurred in the respiratory parameters of the patients included in this study. Significant reductions were found in Total Apnea Hypopnea Index, Total Hypopnea Index, Arousal+Awakening Number ($p < 0.05$) and Awakening Number ($p < 0.01$). The minimum blood oxygen saturation amount of the patients treated with MAD in this study increased insignificantly. This study has some limitations. The first limitation is the small number of participants. Because of the small participant number, the difference between genders was not investigated.

Another limitation is the long term effects of the appliance could not be able to investigate because the participants did not come to post-treatment control appointments and control polysomnographic analysis tests at the 6th and 12th months.

Conclusion

The modified monobloc type, one pieced, unadjustable MAD appliance with 6 mm vertical opening and sagittal advancement amount of %75 maximum protrusion, constructed from dental silicone material was found to be an effective treatment option for snoring and mild OSA. Airway dimensions, airway areas and narrowest sagittal dimension of pharyngeal airway increased significantly. A statistically significant beneficial respiratory changes occurred in PSG tests. The life quality of the patients increased significantly with MAD therapy. Patient cooperation and satisfaction were also provided.

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Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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